Evaluation of Recent VIIRS Sensor Performance in the Coastal Ocean

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Michelle Wood[6,7]

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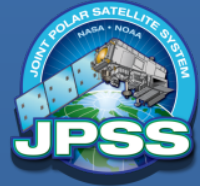[3]San Diego State University, San Diego, CA, USA
[4]QinetiQ Incorporated, Stennis Space Center, MS, USA
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[6]NOAA/AOML Ocean Chemistry Division, Miami, FL, USA
[7]Current Address: Dept. Biology and IE[2], Univ. Oregon, Eugene, OR, USA

Objectives

- **Evaluate current NRL and IDPS VIIRS Environmental Data Products**
  - **nLw (l) – Water Leaving Radiance**
  - **Chlorophyll,   backscattering (bb551)**
- **Coastal AERONET OC Platform Time Series - nLw(l)**
  - **AAOT - Venice, Italy**
- **Calibration & Validation Ship Cruises**
  - **Hawaii (NOAA/Ondrusek)**
    - ✉ **nLw(l)**
  - **Gulf of Mexico (NMFS Cruise – Mitch Roffer, John Lamkin)** ✉ **CHL**
  - **US East Coast (GOMECC2 Cruise – M. Wood)**
    - ✉ **nLw(l)**
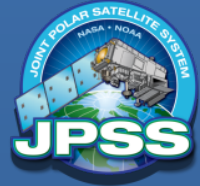
VIIRS – NPP Operational Software for Ocean Color Processing

1. **n2gen software (NRL,NASA) – R&D**
   1. Calibration applied to SDR (AFWA/NAVO)
   2. Atmospheric correction – GW NIR w/ 80 aerosol models
   3. Glint / Cloud Removal
   4. In water Algorithms – QAA - Coastal iteration

2. **NOAA Operational IDPS From CLASS (Mx6.0, Mx6.5)**

Research Software #1 used to evaluate VIIRS sensor

npp.2012216. | Algorithm | Fri Aug 3 18:03:45 2012 | GMTCO-VOCCO.npp.d20120803.USEastCoastGS.L2_Mosaic.hdf

August 03, 2012

CURRENT NRL APS OPERATIONAL SYSTEM

Cloud Masks Similar

4

9

FUTURE Mx6.6 IDPS OPERATIONAL SYSTEM PLANNED FOR JANUARY 2013

Inland lakes

Higher

13

aqua.2012216.0803.D.L3_Mosaic.modis.EGS.v10.1000m.hdf   Fri Aug 3 16:35:28 2012
Chlorophyll Concentration, OC3 Algorithm

Aqua

4.7

0.01   0.054   0.29   mg m^-3   1.6
LAND   CLDICE   ATMFAIL
chlor_a (provisional)
US East Coast w/ Gulf Stream (VIIRS-npp)
Version 1 (APS v4.8.2)
Code 7330/Ocean
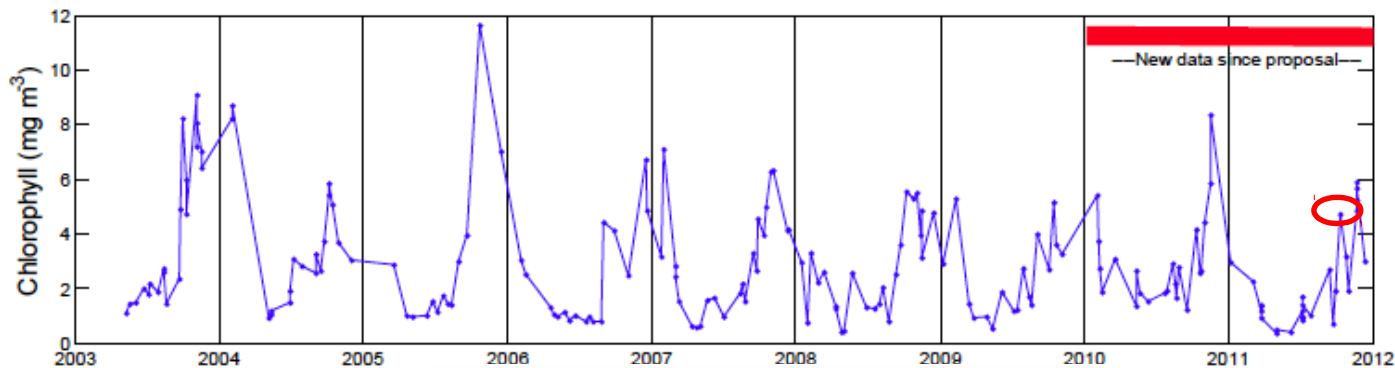Naval Research L
Stennis Space Ce

0.01   0.054   0.29   mg m^-3   1.6   8.4   45
LAND   CLDICE   ATMFAIL
chl_oc3 (provisional)
US East Coast w/ Gulf Stream (MODIS-AQUA-PM)
Version 10 (APS v4.8.1)
Code 7330/Ocean Sciences
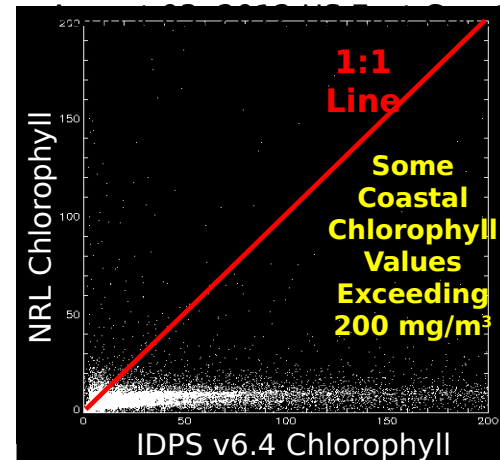Naval Research Laboratory
Stennis Space Center, MS

0.29   1.6   8.4   45
Code 7330/Ocean Sciences
Naval Research Laboratory
Stennis Space Center, MS

Coastal Chlorophyll Retrievals from VIIRS Martha Vineyard's Coastal Observatory (MVCO)

Average Chl range MVCO = 4-6 mg/m3 (August 2011)

VIIRS US East Coast
August 03, 2012 (41.528N, -70.254W)

CHLOROPHYLL VALUES
4
13

NRL vs. IDPS v6.4

1:1 Line

Some Coastal Chlorophyll Values Exceeding 200 mg/m³
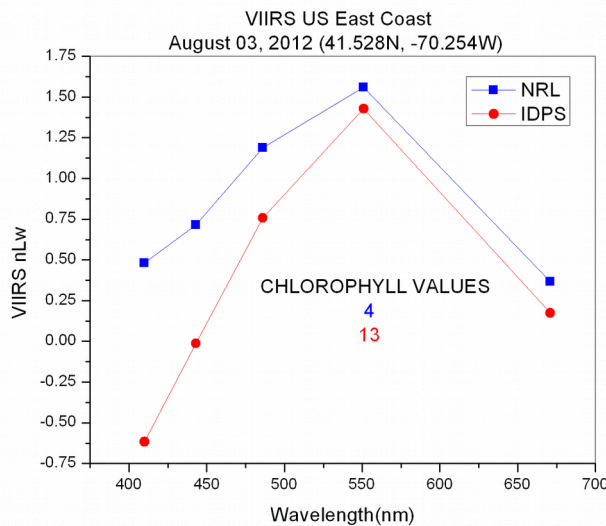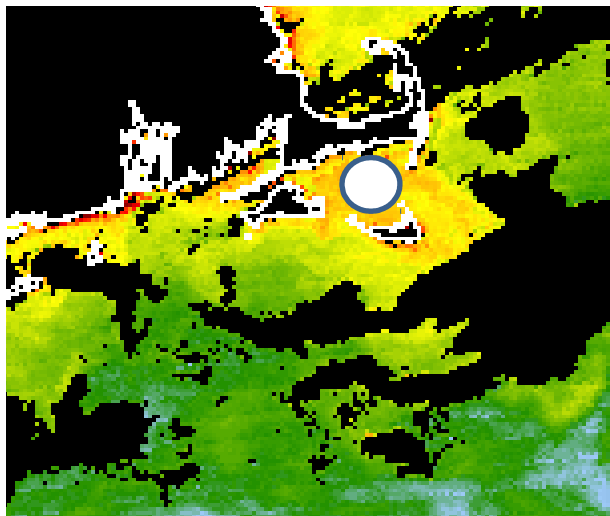
1. IDPS processing Chlorophyll is to high
2. N2gen retrieving accurate Chl .
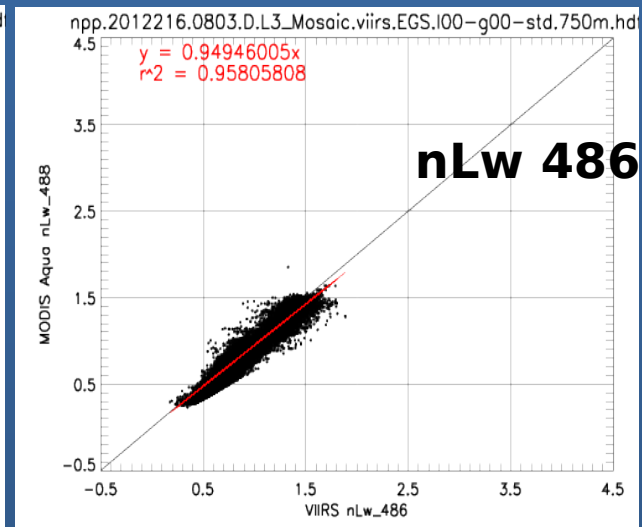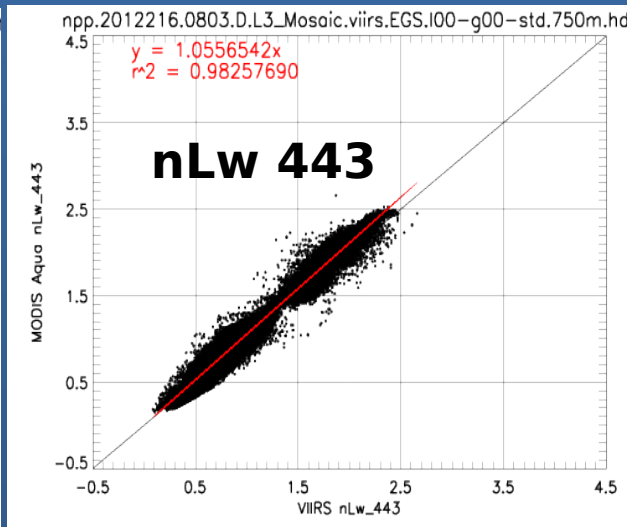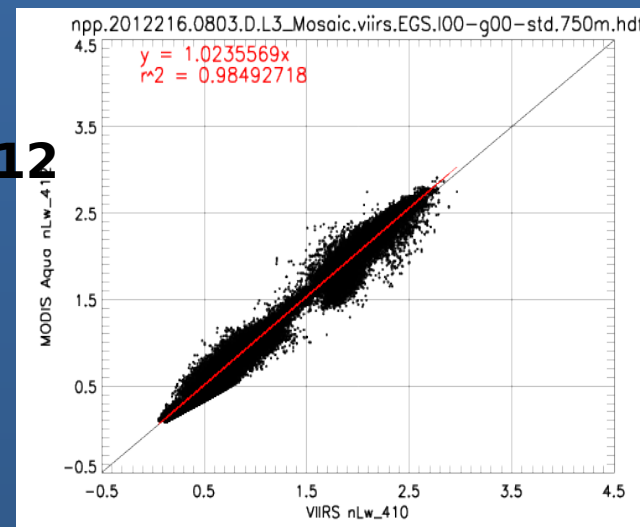**VIIRS Sensor is showing good agreement with observations**

n2gen Inter-Sensor Matchups (VIIRS vs MODIS n2gen)
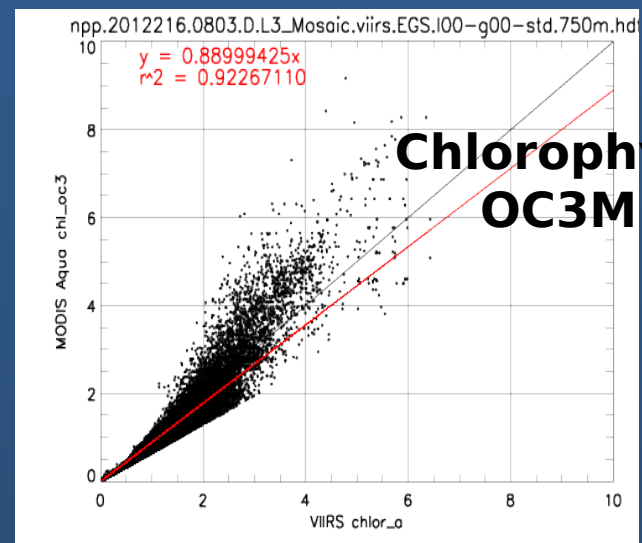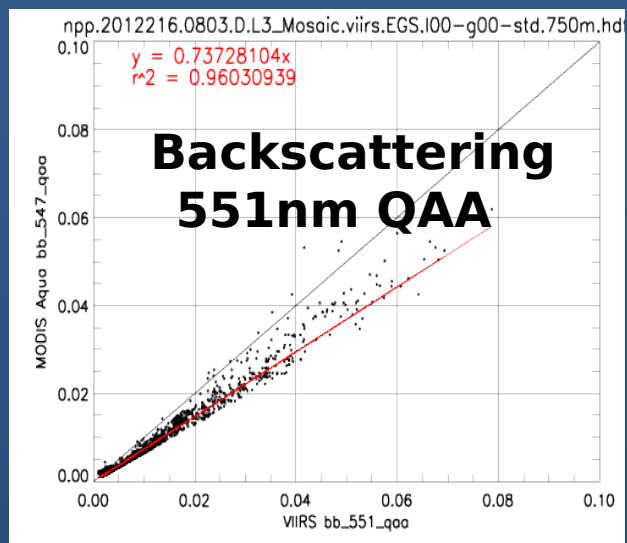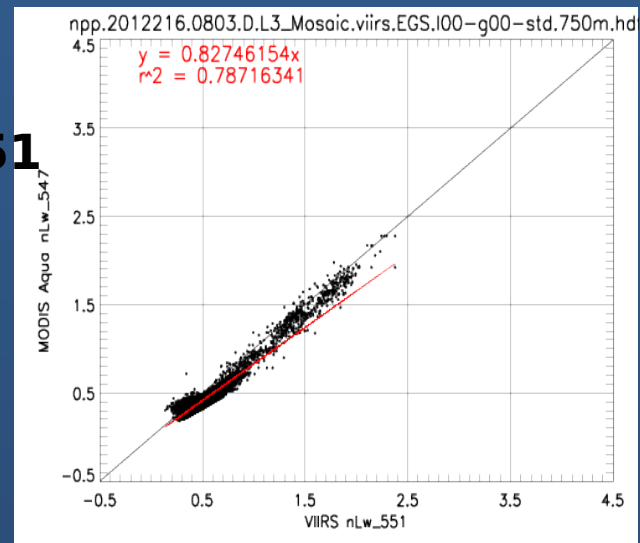US East Coast – August 03, 2012
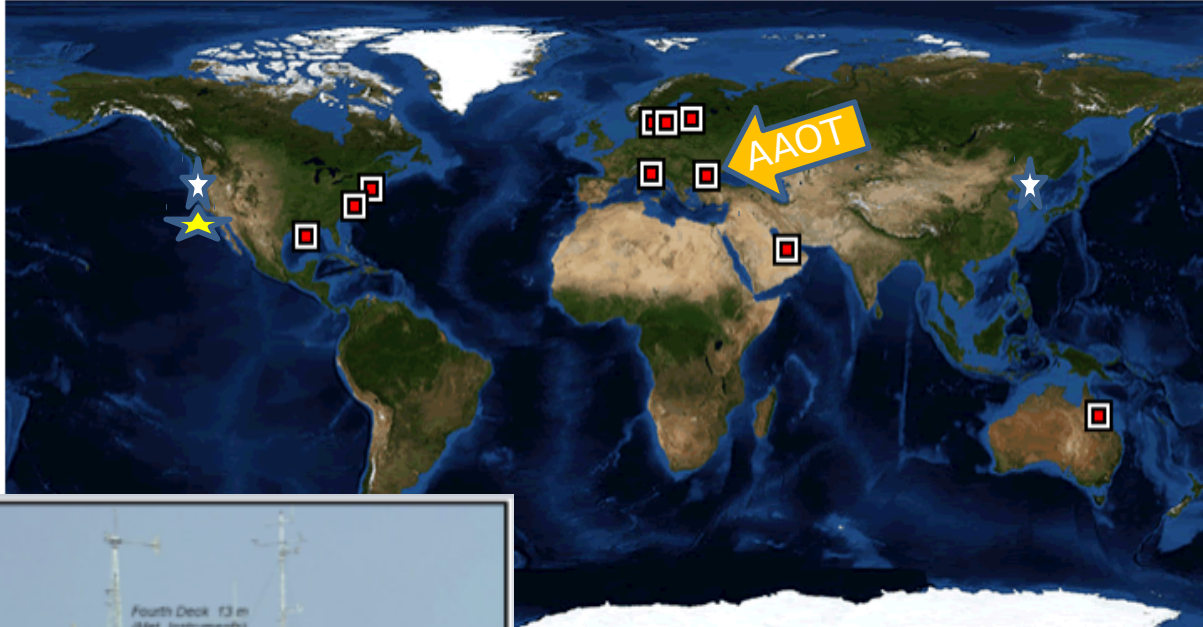
VIIRS = 1803 GMT   AQUA = 1810 GMT

MODIS Aqua agree well and are within time and space uncertainty of th

NASA AERONET-OC (GLOBAL NETWORK)
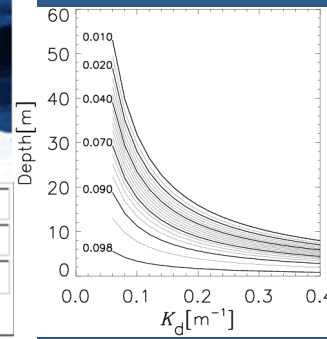
15 Sites that have measured L2 data – nLw(l)

These sites have met the deployment requirements:

1) Platform for unobstructed sky and sea viewing;

COVE_SEAPRISM (36N,75W)	Gloria (44N,29E)
Helsinki_Lighthouse (59N,24E)	Lucinda (18S,146E)
Palgrunden (58N,13E)	Venise (45N,12E)

SeaPrism

effects

Water depth at which the bottom perturbation adds a contribution of 1% to the SeaPRISM LWN as a function of seawater diffuse attenuation coefficient Kd and irradiance reflectance R (the latter values are defined by the curves in black) assuming a Lambertian seabed irradiance reflectance RB=0.10.

The observed surface area should be at a distance from the main superstructure larger than the height of the

3 New Coastal US Sites:

LISCO Site: Western Long Island Sound

WaveCIS_Site_CSI_6' site: Gulf of Mexico

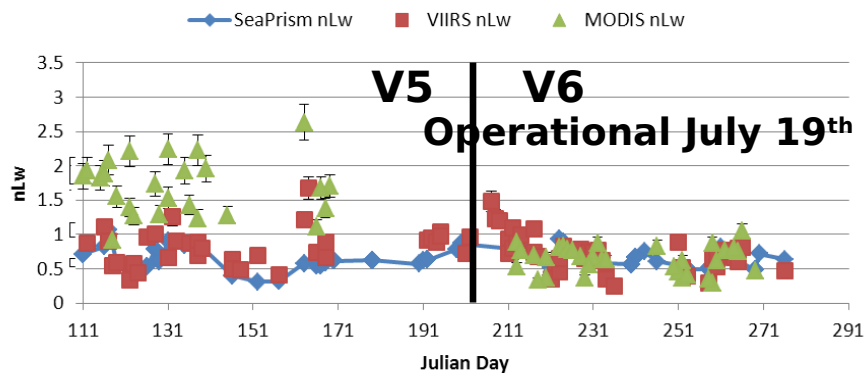**Eureka - UCS site:** South California Bight (Newport Beach)
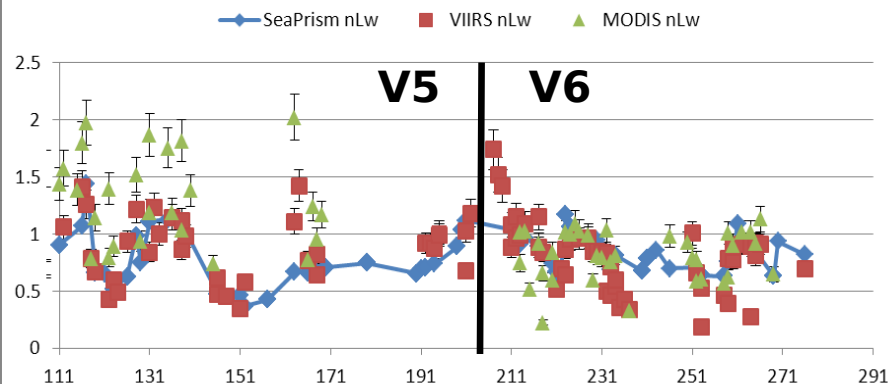
2) Superstructure perturbations

l2gen - nLw Matchup @ AAOT – Venice Italy
April – October 2012
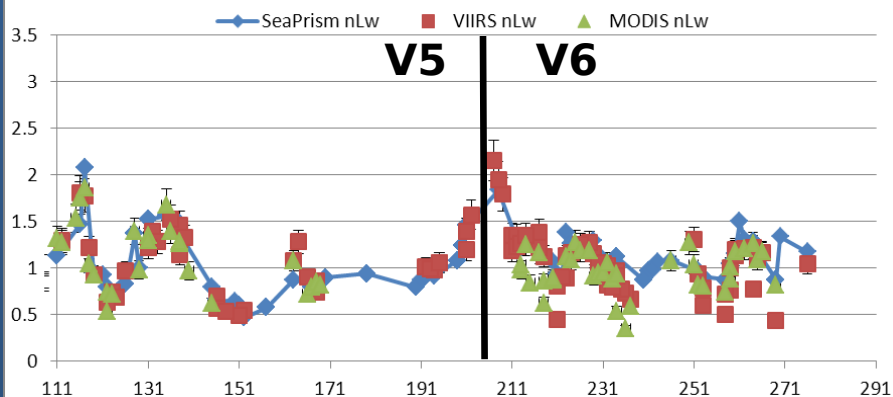

AAOT Time Series (412 nm) 2012
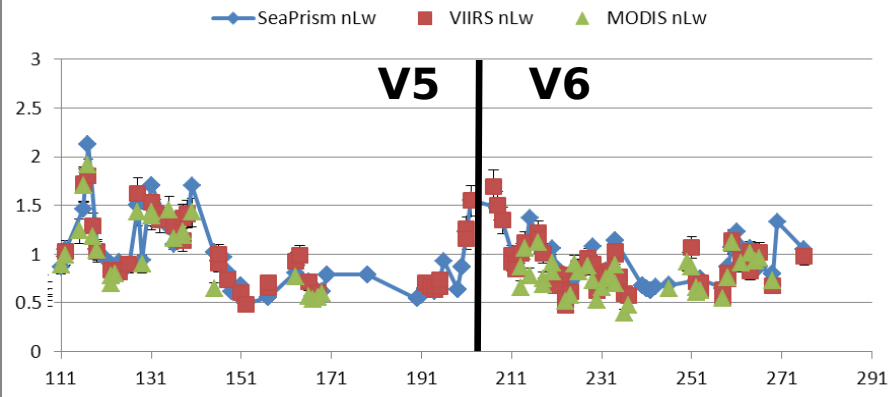

AAOT Time Series (443nm) 2012

AAOT Time Series (490 nm) 2012

AAOT Time Series (551 nm) 2012

	SeaPrism:MODIS			SeaPrism:VIIRS		MODIS:VIIRS	
gth	slope	r^2	slope	r^2	slope	r^2	
1.0205	0.9634	1.0444	0.9640	0.9733	0.9140		
0.9905	0.9821	0.9223	0.9820	0.9243	0.9554		
0.9002	0.9911	0.9602	0.9954	1.0725	0.9879		
0.8981	0.9872	0.9542	0.9885	1.1039	0.9888		
0.4157	0.8252	0.7060	0.9313	1.3780	0.9837		

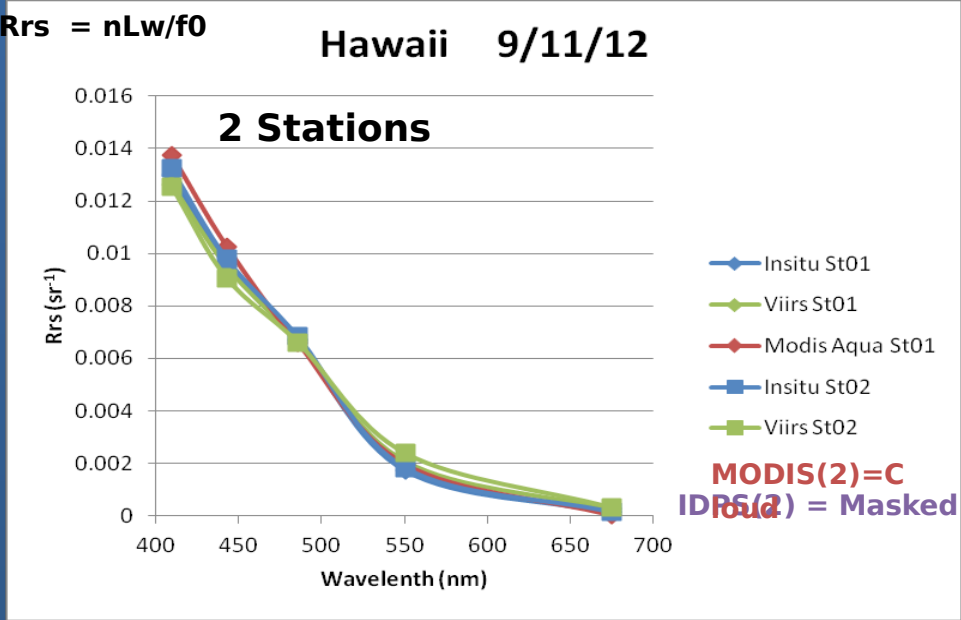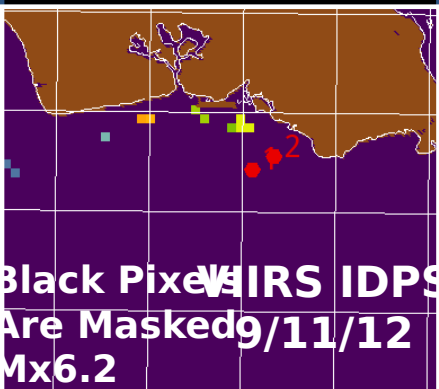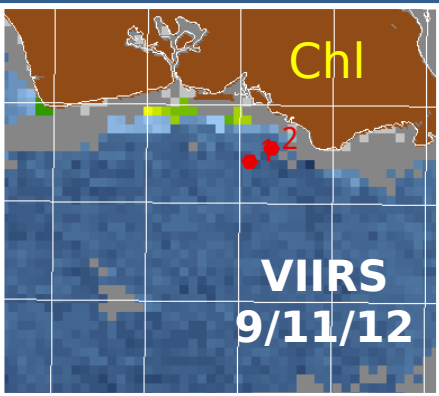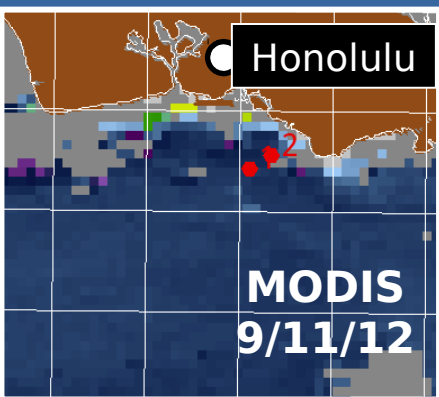**MCST Look-up Tables (Temporal RVS)**

V5 = Calibration Issue with 412 & 443nm (SeaWiFS Cross-Calibration)

n2gen VIIRS/MODIS Rrs vs Hyperpro Matchup
Hawaii: September 08-18, 2012

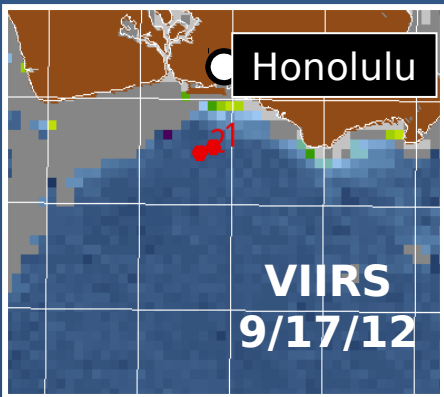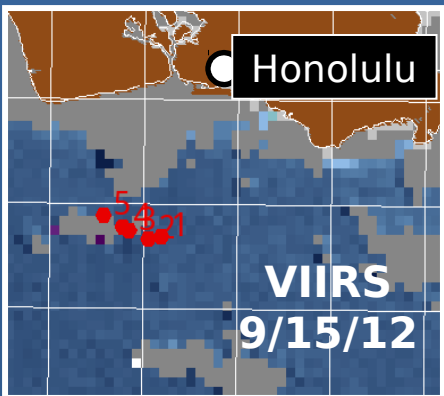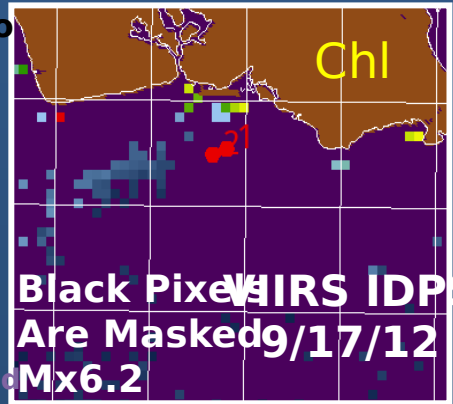Rrs = nLw/f0

Honolulu

MODIS 9/11/12

Chl

VIIRS 9/11/12

Black Pixels Are Masked Mx6.2 **VIIRS IDPS 9/11/12**

MODIS 9/12/12

Chl

VIIRS 9/12/12

Black Pixels Are Masked Mx6.2 **VIIRS IDPS 9/12/12**

Hawaii   9/11/12

2 Stations

Rrs (sr^{-1}) vs Wavelenth (nm)

- Insitu St01
- Viirs St01
- Modis Aqua St01
- Insitu St02
- Viirs St02

MODIS(2)=C loud
IDPS(2) = Masked

Hawaii   9/12/12

1 Station

Rrs (sr^{-1}) vs Wavelength (nm)

- Insitu St01
- Viirs St01
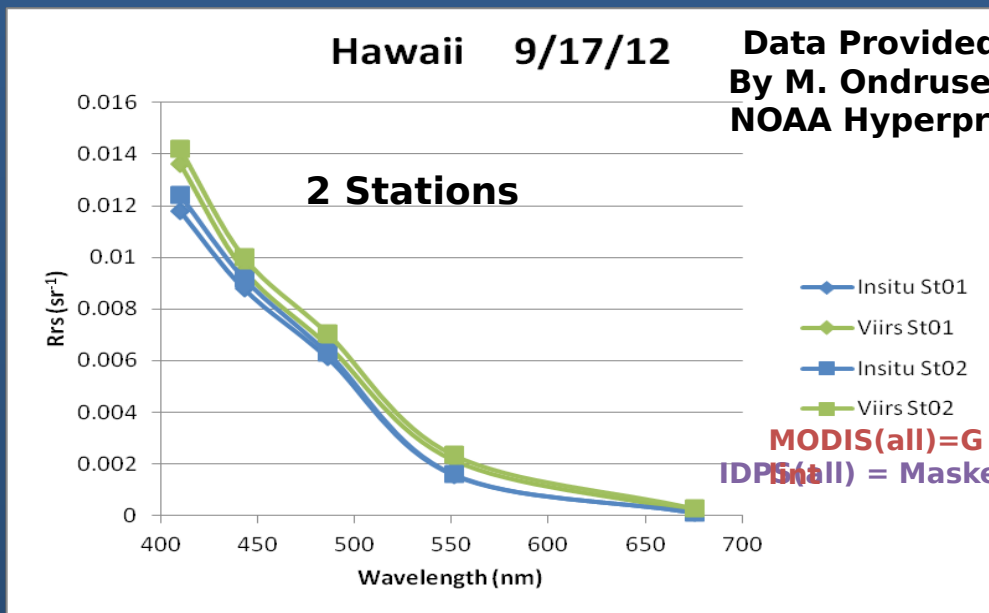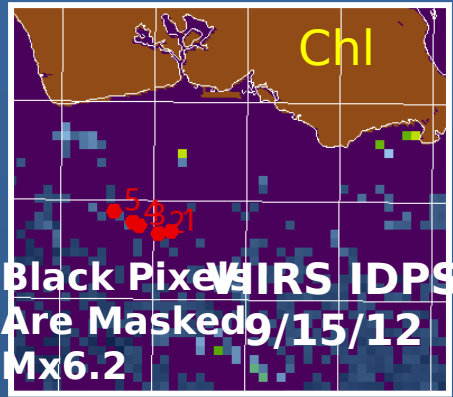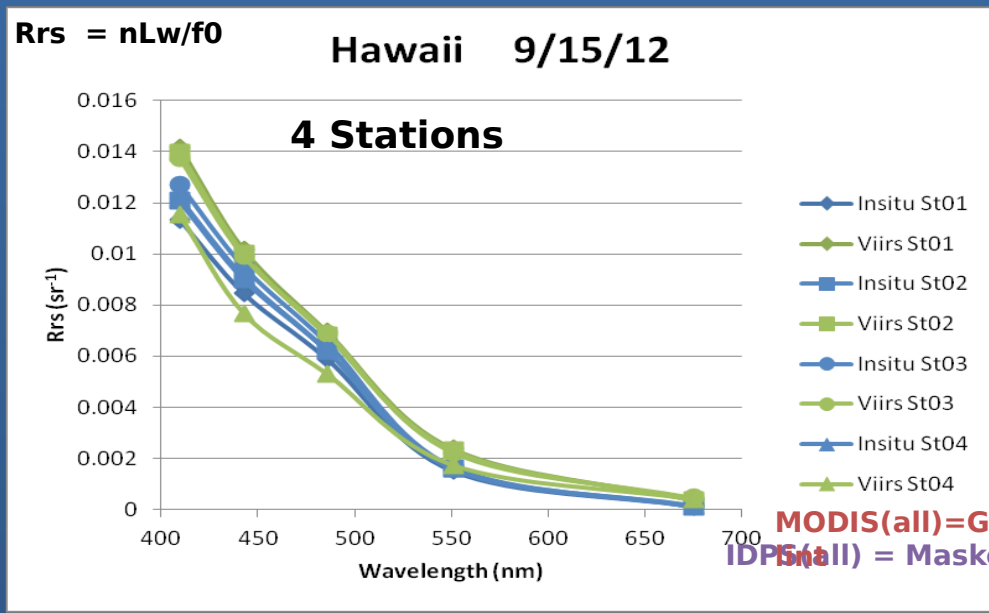- Modis Aqua St01

IDPS(1) = Masked
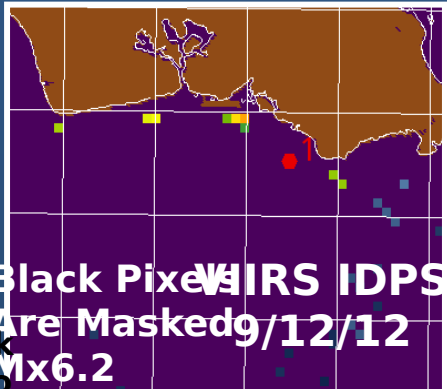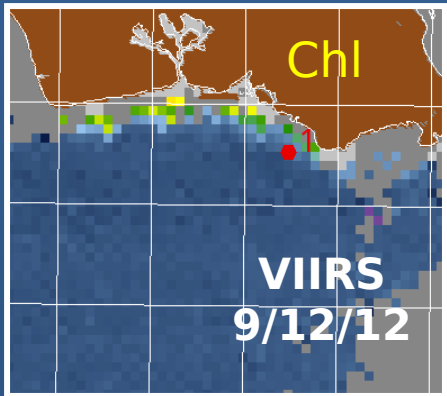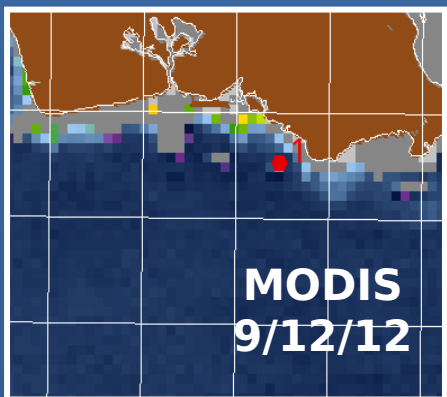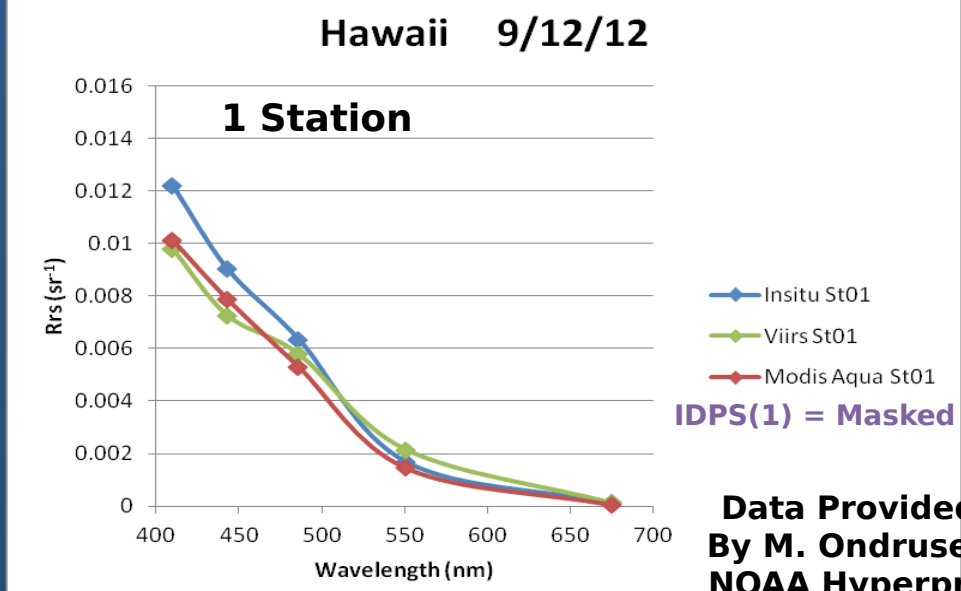
Data Provided By M. Ondrusek NOAA Hyperpro

n2gen VIIRS/MODIS Rrs vs Hyperpro Matchup
Hawaii: September 08-18, 2012

n2gen VIIRS/MODIS Rrs vs Insitu Matchup
GOMECC2: July 22 – August 13, 2012

Aqua FL

VIIRS FL

Glint

Aqua FL

Glint

Glint

GOMECC2 7/26/12

$Rrs = nLw/f0$

1 Station

Rrs (sr^{-1})

- Insitu St01
- Viirs St01
- Modis Aqua St01

IDPS(1) = NA CLASS

Wavelength (nm)

GOMECC2 7/27/12

2 Stations

Rrs (sr^{-1})

- Insitu St01
- Viirs St01
- Modis Aqua St01
- Insitu St02
- Modis Aqua St02

VIIRS(2) = Glint
IDPS(2) = Masked
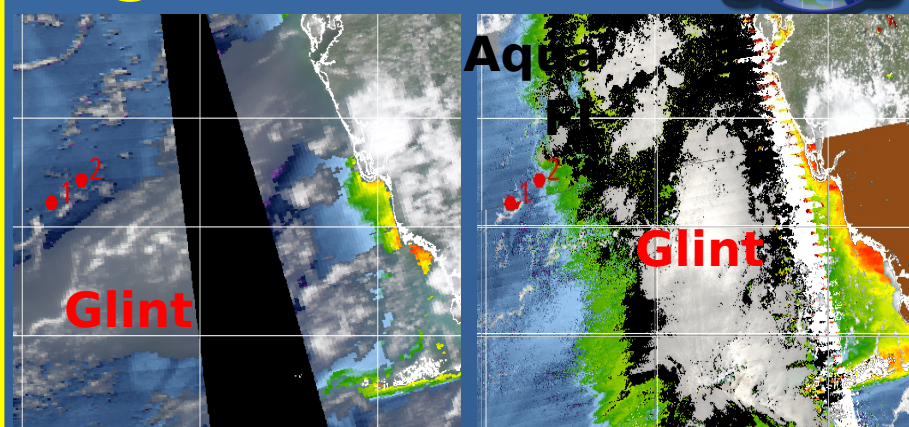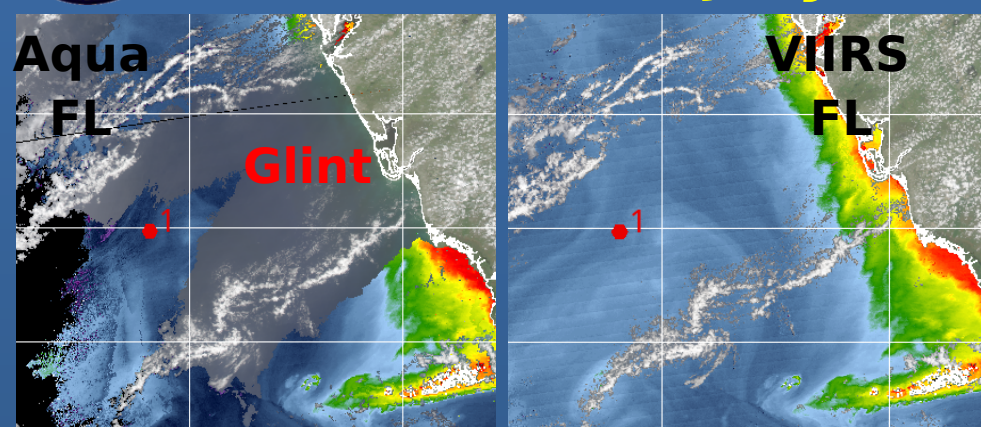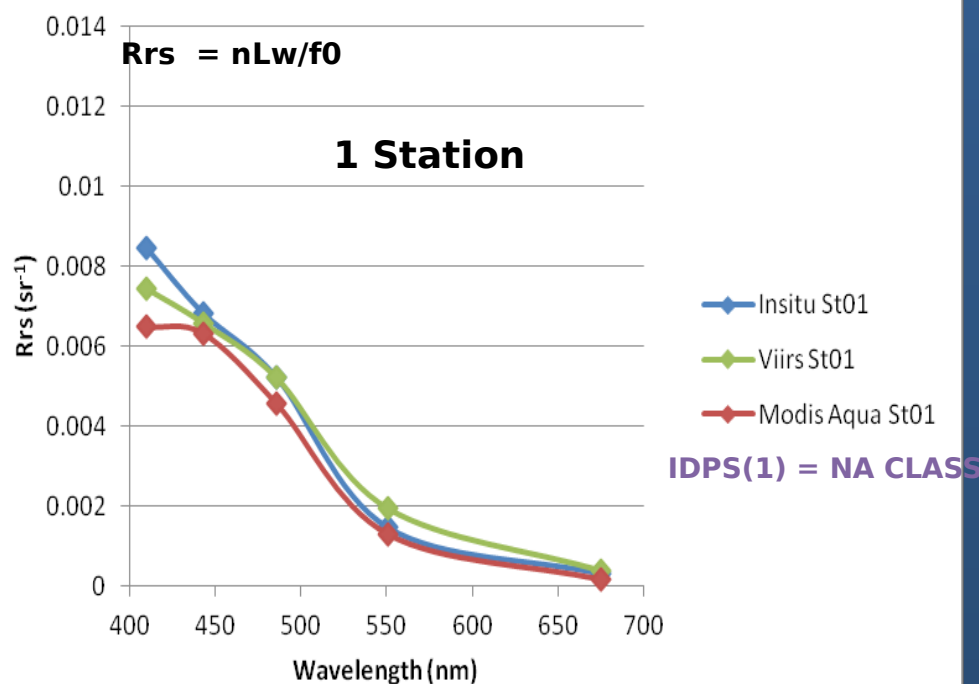
Data Provided By M. Wood NRL ASD

Wavelength (nm)

n2gen VIIRS/MODIS Rrs vs Insitu Matchup
GOMECC2: July 22 – August 13, 2012
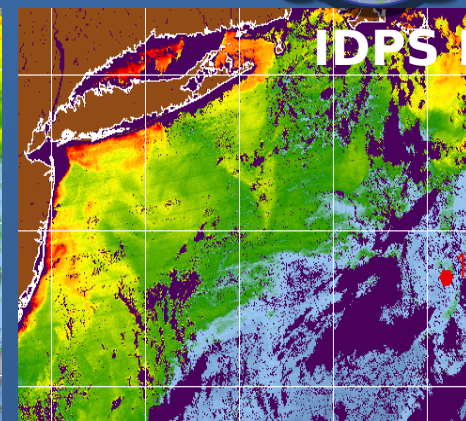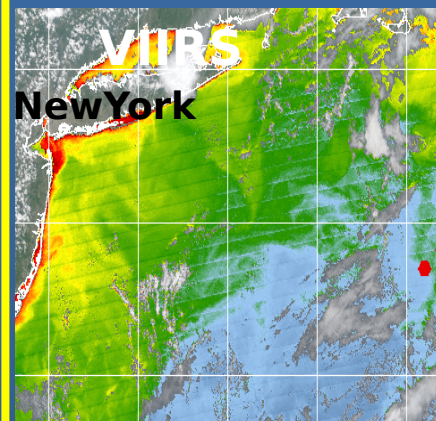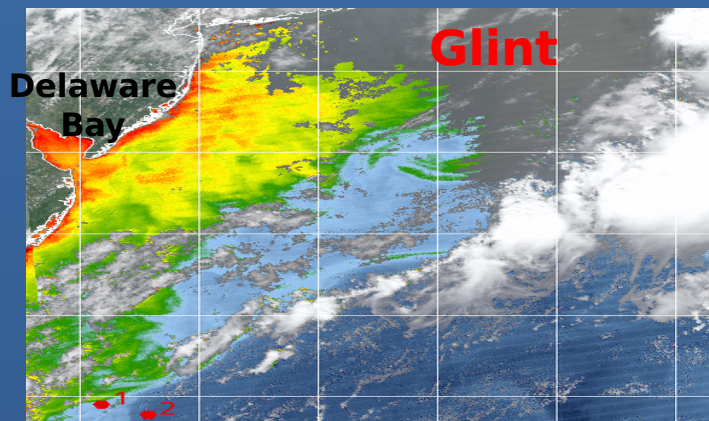

Glint

Delaware Bay

VIIRS

NewYork

IDPS

GOMECC2   8/5/12

$Rrs = nLw/f0$

2 Stations

- Insitu St01
- Viirs St01
- Insitu S02
- Viirs St02

MODIS(all) = Cloud
IDPS(all) = NA

GOMECC2   8/9/12

1 Station

- Insitu St01
- Viirs St01
- Idps St01

MODIS(1)= Glint

Data Provide By M. Wood NRL ASD

Gulf of Mexico Cruise: April 02 – May 28 2012

Gulf of Mexico Cruise – April 02 – May 28, 2013

Legend:
- ▲ NRL Viirs w/Gains (n=71)
- ◆ NRL Viirs (n=71)
- ◆ IDPS Viirs (n=22)
- ■ Insitu (n=190)

IDPS

NRL n2gen ~55% More Retrievals Than IDPS (Masking)

Chlorophyll vs Station #

Insitu vs VIIRS CHLOROPHYLL

Bias [avg(logC1-logC2)] = 0.088
RMSE[avg(logC1-logC2)²] = 0.029
Average Relative Error = 13.4%
N = 71

Satellite chlorophyll (mg/m3) vs Insitu Chlorophyll (mg/m3)

◆ Insitu v VIIRS chl

Errors in VIIRS CHL compared to insitu CHL

- **NOMAD Database**
- **Global SeaWiFS Distribution**
- **NRL Matchup Dataset**

Campbell & O'Reilly, 2006

log(VIIRS CHL) – log(insitu CHL) vs Insitu Chlorophyll (mg/ m3)

14

Panama City, FL Slocum Glider Deployment

bb532   11/08/12   IDPS
bb532   11/09/12   IDPS
bb532   11/10/12   IDPS

Panama City, FL   VIIRS
Panama City, FL   VIIRS
Pan City   VIIRS
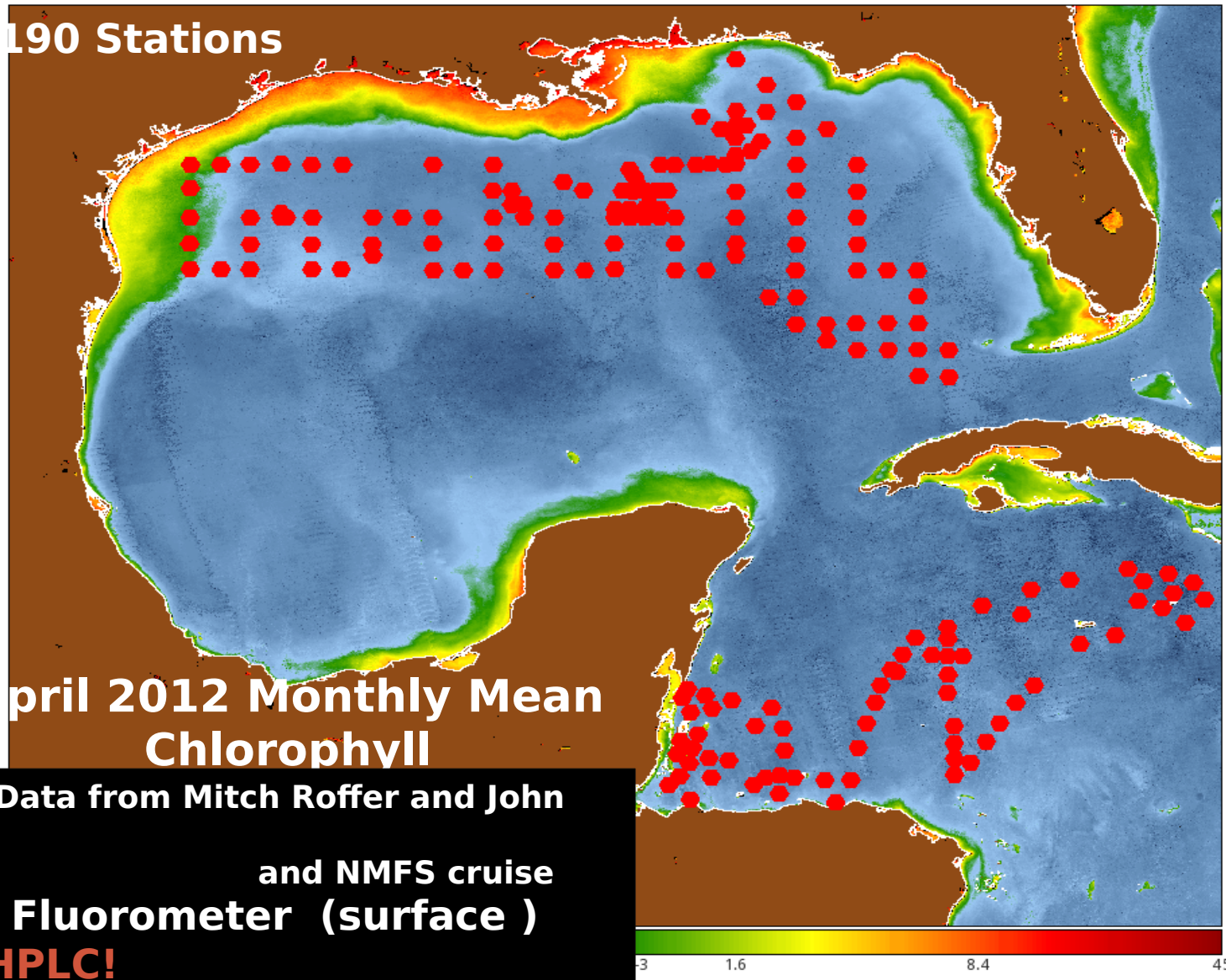
Insitu (glider) vs. Satellite (VIIRS,IDPS) Backscattering 532nm Glider Near Surface (<2m)

0.002   0.0033   0.0055   m^-1   0.0091   0.015   0.025
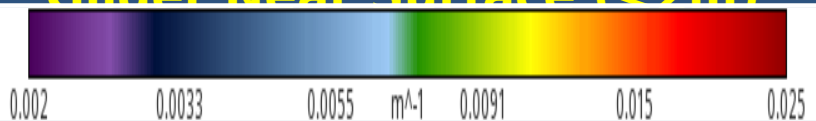
ifferences in Processing erosol models, IOP Algorithm, etc.

Average Relative Error = 5.75%, 13.24%

11/08   11/09   11/10

bb 532nm

Glider 1514 – 2131
Glider 1850 – 2212
Glider 1500 – 2112

VIIRS 1850
VIIRS 1905
VIIRS 1846

Glider
n2gen
IDPS

Sample #
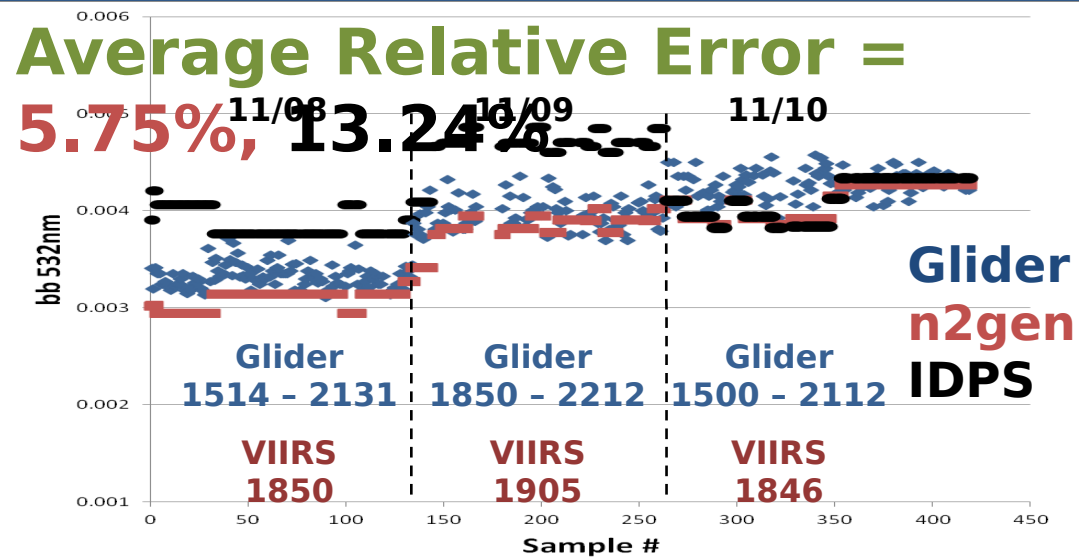
Summary : VIIRS Ocean Color

- **Evaluated VIIRS ocean color EDR products using processing from NRL's n2gen (R&D) and VOCCO (IDPS)**

- **VIIRS Coastal Ocean Color EDR's (nLw/Rrs, Chlorophyll and bb 551) compare well with insitu Ship/AERONET-OC and MODIS**

- **IDPS EDR's products are over masking (Mx6.0-6.5) – limited matchups**

- **Update of IDPS EDR's (Jan 2012 - Mx6.6)**
    - **- suggest setting / using quality flags**

- **Monitoring sensor and radiometric calibration stability using global validation network ✉ requires IDPS updates (Mx6.6)**

- **Follow-on cruises and validation planned in near future**

Questions?

nsor Acknowledgements:

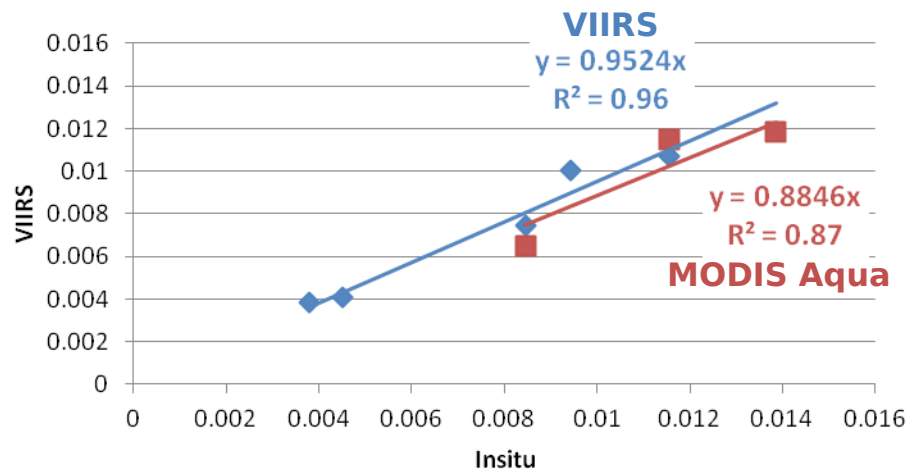JPSS Program Office
NOAA Ocean Acidification Program (GOMECC2
Cruise)

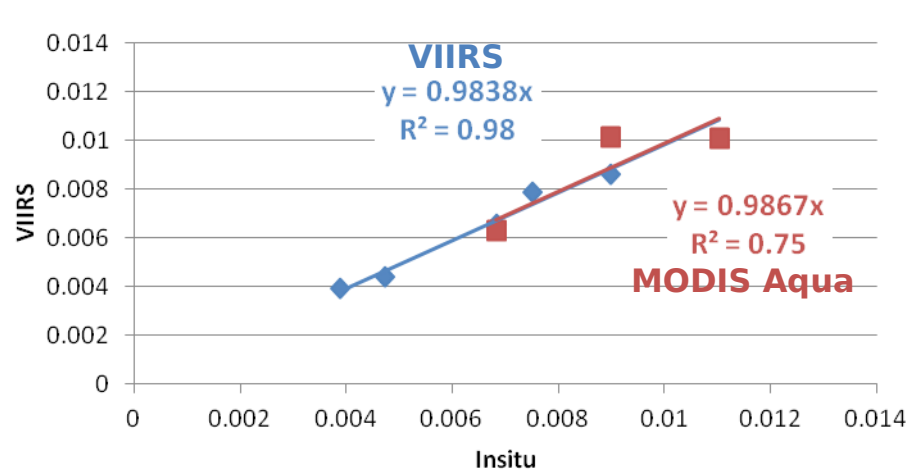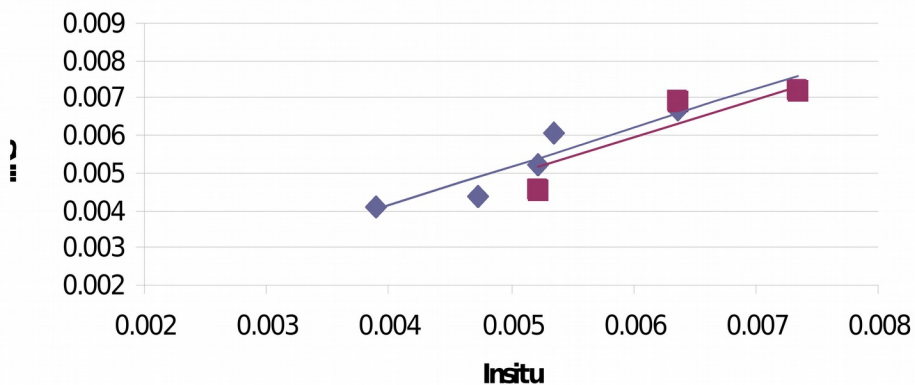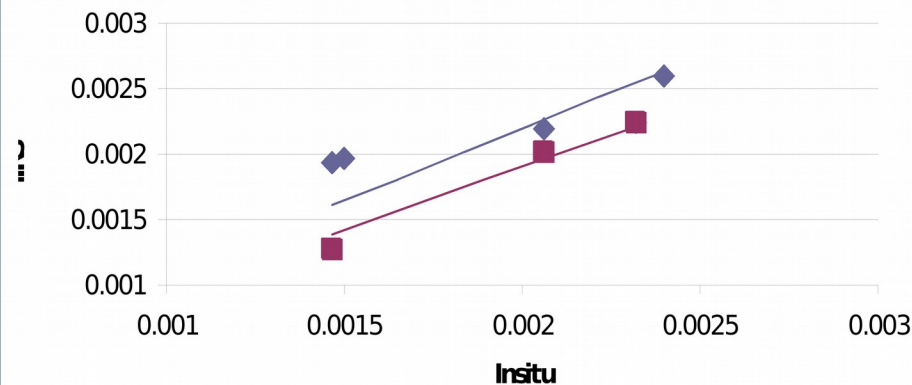# n2gen VIIRS/MODIS Rrs vs Insitu Matchup GOMECC2: July 22 – August 13, 2012

Comparison of Processing Software Packages IDPS and NRL APS (n2gen)

	IDPS	N2Gen/APS
Aerosol LUT model	Wang (12 models)	Ahmad/Fraser (80 models)
Correction Algorithm Basis	Gordon and Wang	Gordon Wang with NIR correction
Gaseous Absorption Species	O_3, H_2O, and other constant species	same as NASA O3 H2O and O2
"Bright Pixel" correction	no	Bailey/2010
Gaseous Absorption RSR (detector averaged)	Absorption coefficients based on V2 Fused RSR	Absorption coefficients based on "V3 New-Fused" RSR
Solar Spectrum	MODTRAN	Thullier 2003
Rayleigh LUT	Generated by Wang using TVAC RSR	following NASA
Diffuse Transmittance	2 component Gordon Yang (Center wavelength only)	following NASA/Frasier
Glint Mask model/angle	VIIRS Cloud Mask / 36 degrees cone	Cox Monk/combination of 36 and other things
Sun glint correction / threshold	Gordon Glint Mask /0.005 with contamination correction	Bailey and Wang/0.01 with contamination correction
Wind speed input data	NCEP GFS/forecast data	"climatology for the real time"
Cloud Mask	VIIRS	using same as Wang right now
Whitecap Correction (wind speed cap)	8 m/s	8 m/s
Bright Pixel (Stray Light Exclusion) Algo.	Quality flag based on scattered light	same as MSL12
How often F-tables are implemented?	weekly	weekly
Polarization LUT	Ambient Test data	same as NASA
Polarization LUT Band or Detector	Detector dependent	detector averaged
RSR used in Rayleigh gain LUT	MX5.3 (Fused RSR) / MX6.2 (New-Fused RSR)	same as Wang
Sensor Zenith Angle exclusion	53 degrees	57 degrees
Solar Zenith Angle exclusion	70 degrees	70degrees
OCC		
Land/Water Mask	QST 2001 LWM and 2005 MODIS	UMB using the full resolution 250m LWM
Chlorophyll Algorithm	OC3V	OC3V
Chlorophyll Coefficients	NASA coefficients	NASA coefficients
IOP algorithm	Carder	QAA

Table 2 provides a summary of the algorithm differences between the IDPS (L2Gen) and APS (N2Gen) processing.
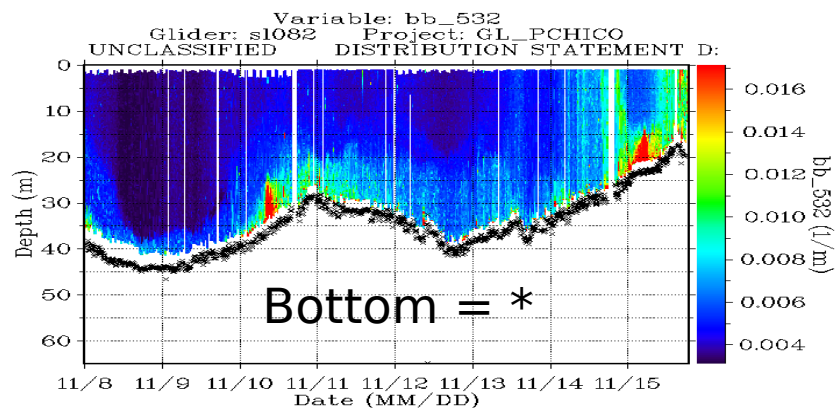
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[8] The IDPS processes JPSS satellite data to provide the environmental data products (Scientific Data Records, SDRs and Environmental Data Records, EDRs).
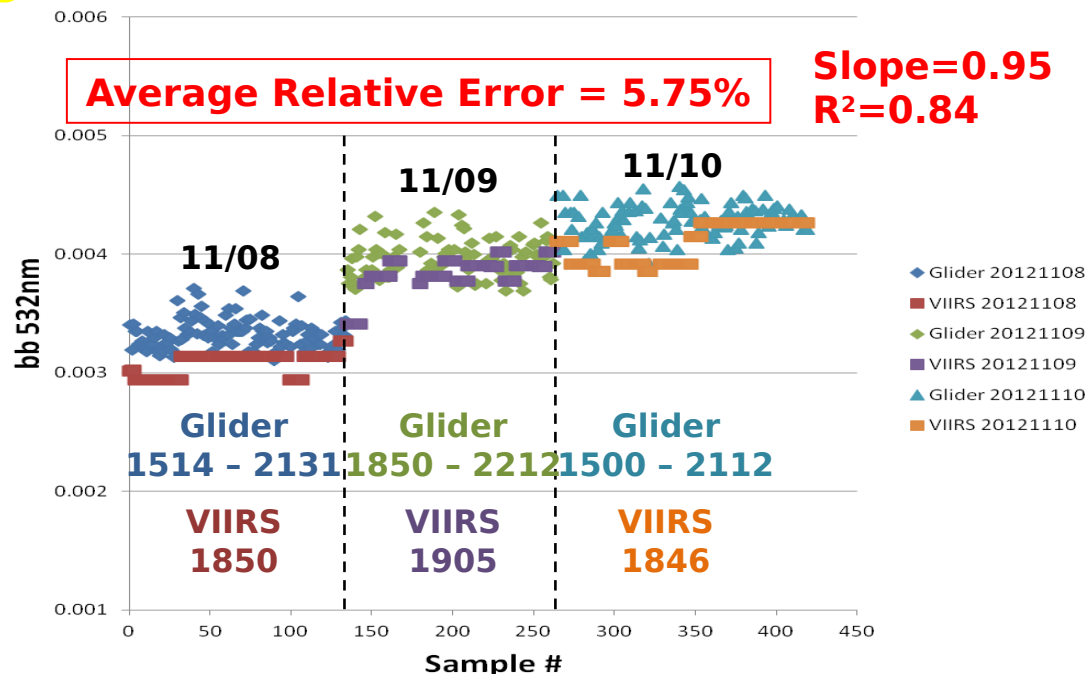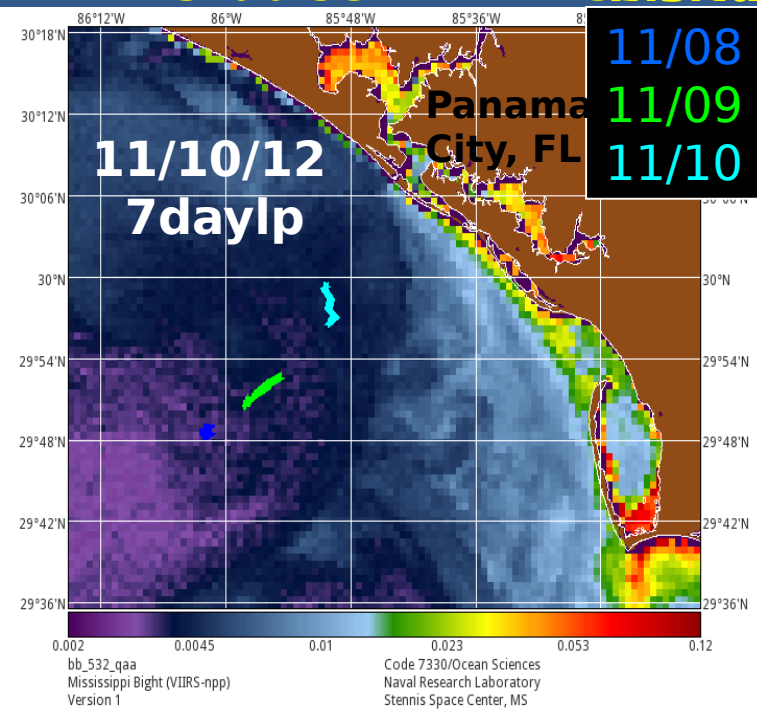
Panama City, FL Slocum Glider Deployment
November 08 – November 16, 2012

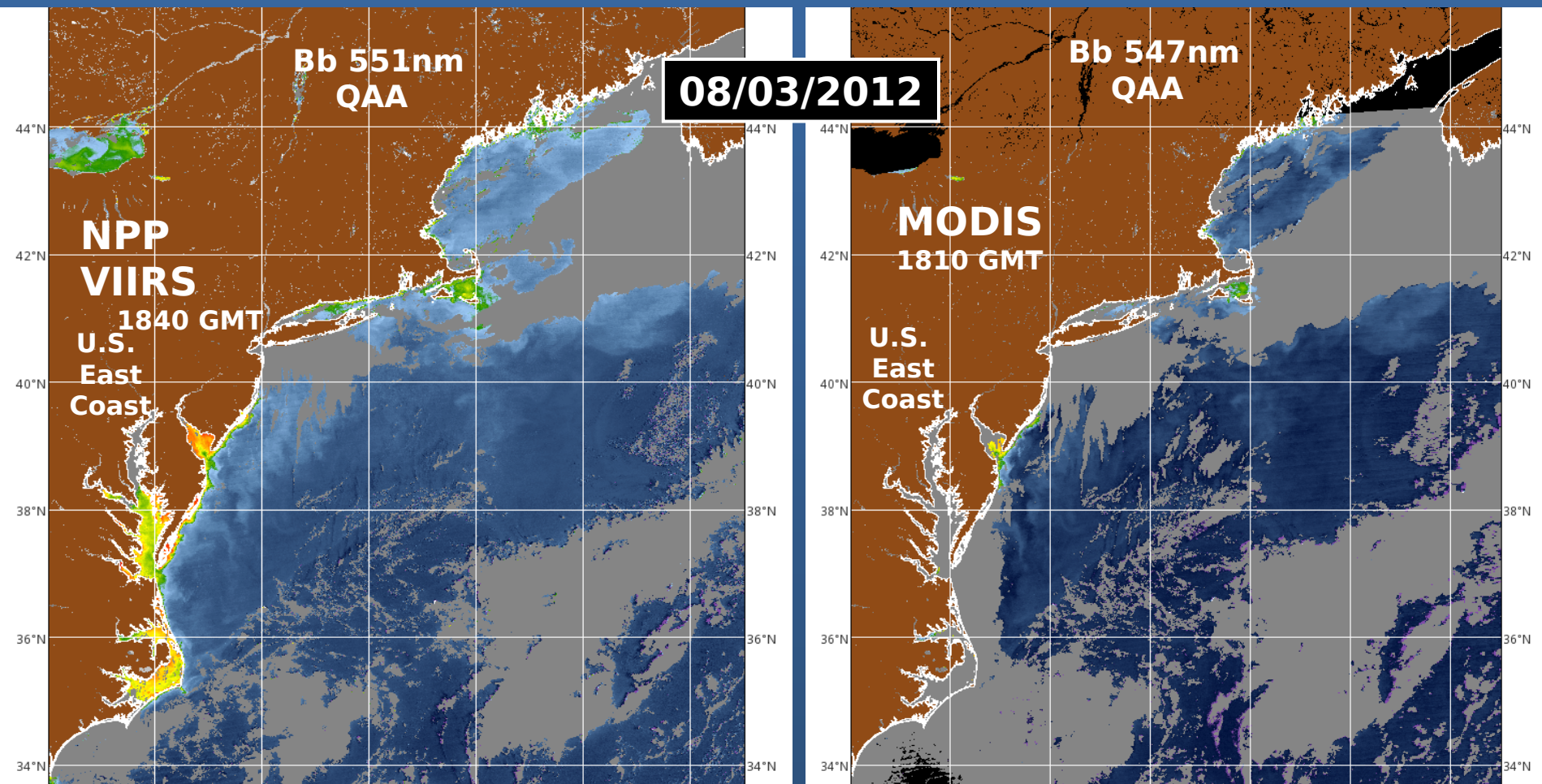**bb 532 Time Series (Entire Deployment)** Slocum Glider

VIIRS bb 551nm -> 532nm (glider) vs. Satellite (VIIRS) – Near Surface

Inter-Sensor Matchups (VIIRS vs MODIS n2gen)
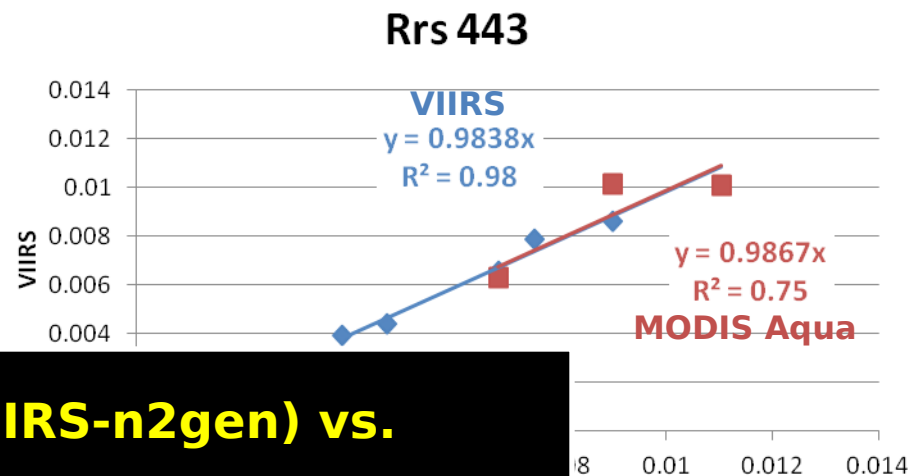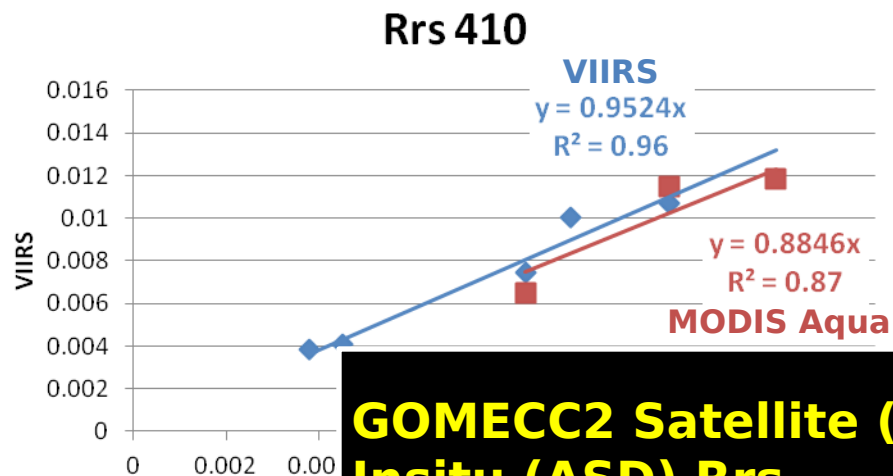Navy Ocean Optical Backscattering Product – US East Coast

GOMECC2 Satellite (VIIRS-n2gen) vs. Insitu (ASD) Rrs

Average Relative %Error:		
	410nm	443nm
486nm	551nm	